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ABSTRACT

Arguing that the failure of instructional materials is frequently due to misconceptions held by their developers concerning the nature of comprehension, this chapter examines the factors involved in comprehension and relates them to the design of instructional materials. Three types of errors in comprehension are discussed, and ways to avoid them are presented: (1) instructional materials fail because of a lack of background, either already possessed by the student or to be provided by the materials; (2) instructional materials fail to provide a useful context for the instruction presented; and (3) instructional materials fail because of interference from various aspects of the instructional materials themselves. Some conclusions about comprehension are provided to aid in the designing of materials which avoid these problems. The text is supplemented with two figures, and an eight-item bibliography is provided. (Author/EW)

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CHAPTER IV

COMPREHENSION AND THE DESIGN OF INSTRUCTIONAL MATERIALS

By

Buford E. Wilson

THE NATURE OF COMPREHENSION

Many times instructional materials and strategies fail or are only partially successful because of misunderstanding about the nature of comprehension. In this chapter we will examine some of the factors involved in comprehension and see how these factors are related to the design of instructional materials. Although the points I intend to make are true of comprehension in general, this paper will focus upon the understanding of language.

Typically, understanding what another person says seems to be a smooth, effortless, automatic process. People speak and we just know what they mean. Partly as a result of this ease of understanding words we are led to false conclusions about the way that words work in allowing us to understand other people's spoken and written messages. It seems natural to assume that we learn words and their meaning together and that when we hear words their meanings are evoked; understanding is no more than being aware of the meanings of the words. Words function in language, the story goes, as symbols or representations of meanings. The word is heard or seen; its meaning is evoked, and understanding occurs.

As we shall see, this seemingly natural set of assumptions about the way words work is inaccurate and can be detrimental to the development of instructional materials. Words do not function as referents of objects or meanings, rather, words act as cues on the basis of which we construct meaningful interpretations of messages or interactions. For example, the words "How are you?" can mean a wide variety of things depending upon how they are said and the context in which they occur. Frequently, we assume that, "how are you" is not really a question in need of an answer, but a form of greeting that can vary from friendly to coldly polite. In the situations where it is in fact a question, it can have many meanings such as: "Are you feeling better now?" if you have been sick, or "Can you continue?" if we are doing something difficult, or a complaint if I haven't heard from you in a long time. In each case the meaning

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of the phrase can be determined by several factors. The listener figures out possible meanings of the phrase using: 1) his knowledge of what is happening between the speaker and himself; and 2) his knowledge of how this might relate to other relevant experiences or aspects of their relationship. The words do not evoke a given set of meanings, rather they act as cues to possible meanings. If you play the game of changing contexts, changing relations between people, and changing the demands of the situation, you can create a seemingly endless set of meanings for the phrase "how are you?" How can this be so? How can words work if the possible meanings they evoke can form such a long list? How does the head keep a record of so many possible meanings for the thousands and thousands of words we know? The answer, as we shall see, is that the meanings are not stored. Rather, the meanings are created in the different situations. Words act as cues for this creation, they do not stand for a list of meanings which are evoked as the words are experienced.

Read the following words slowly with the knowledge that you will be asked to remember them in a few minutes: pillow, spread, bed, rug, slippers, yawn, book, pajamas, dresser, light, robe, awake, alarm, sheet, blanket. Now write down as many of the words as you can remember. About 50% of my students who hear or read this list later remember the word "sleep." "Sleep" however, was not in the list of words. This is not a surprising result if we assume that the words led people to imagine or to construct in their minds a situation or series of events that would occur in a bedroom. Many of these constructions could involve sleeping, or falling asleep, or waking up. If the act of sleeping was a part of the construction then it makes sense to remember or think you heard the word "sleep." The words acted as cues on the basis of which you created possible or likely mental constructions. What you tend to remember is the construction, i.e., what your head builds, not just a copy of the list of words. Consider now what it means to have understood those words. Understanding was an active process, the creation of mental events. It is this active building of mental events which characterizes comprehension. What we understand depends upon the events we construct, and what we learn is contained in these mental constructions.

Similarly, when we listen to people talk or when we read sentences and paragraphs we are rarely able to recall the exact words that were used. What we are usually very good at remembering is the meaning of what was read or said. In a cleverly designed series of experiments, Sachs (1967) presented short stories to subjects. She stopped the story and presented new sentences to the subjects asking them if they were identical to sentences in the story or changed in any way. The subjects

were unable to consistently detect changes in the form of the sentences. However, any change that effected the meaning of the sentences was detected 80% to 90% of the time.

For example, consider the following five sentences actually used by Sachs.

BASE (unchanged):

A wealthy manufacturer, Matthew Boulton, sought out the young inventor.

SEMANTIC CHANGE:

The young inventor sought out a wealthy manufacturer, Matthew Boulton.

ACTIVE TO PASSIVE CHANGE:

The young inventor was sought out by a wealthy manufacturer, Matthew Boulton.

FORMAL CHANGE:
A wealthy manufacturer, Matthew Boulton, sought the young inventor out.

LEXICAL CHANGE:
A rich manufacturer, Matthew Boulton, sought out the young inventor.

The "base" sentence was in the original story. If forty seconds or more had passed since the subject heard the base sentence, the passive/active, formal, and lexical changes were not detected at a level different from chance. In contrast, the semantic change was consistently detected as different. That is, the changes which altered the form but not the meaning of the sentences were difficult to detect, even when this involved changing the exact words used. However, changes in form which also changed the meaning were easily detected. Sach's subjects had knowledge of the meaning of the passages, but they had little knowledge of the exact words in the sentences or the form of the sentences. The words in the Sachs' paragraphs acted as cues for the building of mental constructions and what the subjects tended to remember was the mental construction they had built. Clearly, when we listed to or read words we do not learn copies of the words or sentences themselves, rather we learn the meanings that we construct. Studies such as Sachs' illustrate that the words somehow act as the basis for mental construction and that what we know or remember are these constructions. It is not the case that we remember sentences and repeat them back again so we can remember what they meant. The meaning that sentences have for us are the mental constructions we create when we experience the words.

Bransford, Barclay, and Franks (1972) discuss a series of experiments which investigate the nature of these constructions. Consider

the sentence "Three turtles were sitting on a log when a fish swam beneath them." Subjects who heard this sentence later believed that they had heard sentences which said the fish swam under the log. The event of the fish swimming under the log is implied in the original sentence and would, therefore, be in our mental constructions about the sentence. It is important to note, however, that the event is not described in the sentence or contained in the meaning of the words in the sentence. The event of the fish swimming under the log is implied given what we know about turtles, water, logs and fish and how these objects can interact. It is not contained in the meanings of the words. If we have the appropriate knowledge we can use the words as cues to build a mental construction. What is contained in these constructions goes beyond the meanings of the words used. The event of the fish swimming beneath the log is contained in an appropriate mental construction, not in the meanings of the words in the sentence.

In a related experiment Johnson, Bransford, and Solomon (reported in Bransford and McCarrol, 1975) found that after hearing the following sentences: "John was trying to fix the birdhouse. He was pounding the nail when his father came out to watch him and help him do the work:" subjects frequently believed that they had heard a sentence containing the word "hammer." Again, note, that "hammer" is implied only if you have the appropriate knowledge. In other times or cultures "rock" could have been implied by a similar sentence. Hammer is implied for us because of our knowledge about tools, birdhouses, etc., and it is not in the meaning of the words in the sentence.

To review, understanding is not the awareness of given meanings which we store and bring to mind when the word is experienced. Rather, words act as cues allowing us to create semantic constructions on the basis of knowledge we have about the words, the situation, the objects involved, and the possible interaction of these factors with each other. As the above examples have shown, the content of the construction is more than what is contained in the meanings of the words. The content of the construction depends upon what the listener contributes, it is not predetermined by meanings which are evoked when the words are heard.

If comprehension and learning are to occur, instructional materials and strategies must act as successful cues for the building of mental constructions. To act as successful cues, the instructional materials must direct the learner to knowledge that he already possesses. He can then use this knowledge to build the appropriate constructions.

To this point we have discussed evidence suggesting that words act as cues to allow us to build mental constructions. Now I would like to turn to a consideration of the factors necessary for this construction to

occur. John Bransford and his colleagues have conducted a series of experiments investigating some of the limitations upon peoples' ability to understand and recall verbal material. Consider the sentences: "The trip was not delayed because the bottle shattered. The haystack was important because the cloth ripped." At first, these sentences sound like nonsense and are difficult to remember even a few seconds after they are heard. McCarrol, Bransford, and Johnson reported in Bransford and McCarrol (1975) that subjects were extremely poor at recalling sentences such as these and found them exceedingly difficult to understand. However, the same sentences were not difficult to remember or understand when preceded with appropriate contextual cues: (christening a ship) "The trip was not delayed because the bottle shattered." (parachutist) "The haystack was important because the cloth ripped." When the sentence occurs in a context that provides the listener enough information to create a semantic construction, understanding and memory are relatively easy. When the conditions are such that the necessary information is not present, exactly the same words seem terribly difficult to understand and remember. If understanding was simply a matter of having words evoke meanings, the sentences would be equally understandable with or without the contextual cues. In this case, the listeners knew the meanings of the words in the sentences and had relevant knowledge about the subject matter of the sentences. Yet, they still failed to understand or remember. The sentences did not act as successful cues for the building of appropriate semantic constructions because they did not make it clear which aspect of the listeners knowledge was relevant. Understanding is not automatic even when the problems of word meaning and background knowledge can be assumed to be satisfactorily solved. If an appropriate construction is not built, understanding can not occur.

It is also important to note that the effectiveness of the contextual cues depends upon what the listener already knows. The cues can be helpful only if he has relevant knowledge to which he can refer. It is possible for someone to know the meaning of the words in the sentences and not have knowledge of christenings. In that case the meanings of the words would not be a sufficient condition for understanding the sentence even if the contextual cue (christenings) was present. Understanding entails the successful creation of semantic constructions. The building of appropriate constructions can only occur if the learner has relevant knowledge and knows which aspect of his knowledge is needed in a particular situation. The words don't provide the meaning for the utterances, rather they act as cues for the creation of meaning.

Finally, consider the following paragraph:

> The procedure is actually quite simple. First you arrange things in different groups. Of course one pile may be sufficient depending on how much there is to do. If you have to go somewhere else due to lack of facilities that is the next step, otherwise you are pretty well set. It is important not to over-do things. That is, it is better to do too few things at once than too many. In the short run this may not seem important but complications can easily arise. A mistake can be expensive as well. At first the whole procedure will seem complicated. Soon, however, it will become just another facet of life. It is difficult to foresee any end to the necessity for this task in the immediate future, but then one never can tell. After the procedure is completed one arranges the materials into different groups again. Then they can be put into their appropriate places. Eventually they will be used once more and the whole cycle will then have to be repeated. However, that is a part of life.

This paragraph was used in an experiment conducted by Bransford and Johnson (1974). Subjects showed poor comprehension, and very little ability to recall the words in the paragraph. The problem in understanding this paragraph is not a problem of word meanings. We all know all of the words in the paragraph. The difficulty in understanding this paragraph is a problem of creating a semantic construction which fits the paragraph. Read the paragraph again with the knowledge that it is about the task of washing clothes. Now the same words can provide you with a completely different experience. Notice how you are constructing situations, objects, and relations in your mind. For example, what is the mistake that could be costly? This demonstration shows that the meaning of the words, the meaning of the sentences, and the meaning of the paragraph all depends upon the listener being able to construct a semantic interpretation. When the listener fails at this task, the prose seems to have no meaning. It is not a sufficient condition for understanding that we possess relevant knowledge. All of us possess enough knowledge about washing clothes to understand the paragraph, but we must know what part of our knowledge is relevant to that understanding.

We have seen that words do not have meanings which are stored in the brain and evoked when the word occurs. Rather, words act as cues to the construction of meaningful interpretations which fit the situation in which the words occur. Words act as cues to semantic constructions by directing the listener to knowledge that he already has about objects, events, etc. Understanding consists of using this existing knowledge to build appropriate constructions. These constructions, then, are new knowledge which builds upon what is already known. We use existing knowledge to create new knowledge. Instructional materials and

strategies can only be successful to the degree that they direct the learner to relevant existing knowledge, and lead him to use this knowledge to create new knowledge, i.e., sematic constructions.

IMPLICATIONS FOR INSTRUCTIONAL DESIGN

In the above discussion of the nature of comprehension we described comprehension as an active, constructive, contribution of the comprehender. Understanding was shown to involve the building of mental constructs. When the learners failed to build these constructs little was understood or remembered. To be successful, instructional materials and strategies must be directed toward this goal. Frequently, we learn things through repetition and are able to say them back on cue, but do not really understand them. Many children learn the rhyme: "Mares eat oats and does eat oats and little lambs eat ivy," without becoming aware that the words are meaningful English words. Rather, they learn it as a pleasant sounding rhyme or tune and are not at all cognizant that it is about animals or eating.

In a certain sense, these children have learned the rhyme, that is, they are able to say it back. However, they have not understood the rhyme: they have not acquired the information about what animals eat what. As instructional material about animals' eating preferences, the rhyme was a total failure, even though the children "knew it by heart." Memorizing the rhyme did not insure that it was understood, or that its implications could be grasped (for example, realizing what animals could endanger your ivy plants.)

To understand requires more than making a record or copy of what we have experienced. Understanding requires that we use what we already know to build the mental constructs that contain the new information. What we understand and know is in these constructions, not in copies of what we have experienced.

There are several typical ways that instruction fails when the active contribution of the understander is not acknowledged. In the remainder of this chapter we will discuss three typical instructional errors which occur because of misunderstandings about the nature of comprehension. The first two errors are a result of equating word meanings with knowledge. That is, assuming that word meanings entail the knowledge necessary for understanding.

As we have seen in this chapter, knowing the meanings of words is not the same as understanding those words in a particular situation. Words do not automatically evoke the meanings associated with them; rather, they act as cues which direct us to relevant parts of our knowledge of the world. We then use this knowledge of the world to construct possible meanings of the words in a given situation.

If I say to you "That man is like a giraffe," and he has just been stretching his neck to see over a fence, you will probably assume he has a long neck. But, in fact, I can use the same words to direct you to any knowledge you might happen to have about giraffes. The man may be wearing shorts and have skinny, long legs; he may have on a spotted pair of pants, or chew his food in an unusual manner, or be unable to speak. In fact, the words can direct you to any knowledge you have about giraffes, and their relationships to other objects or events. For example, the sentence could refer to a giraffe on ice, if the man is learning to skate, or a giraffes' relation to objects like trees if the man is able to reach high places. Depending upon the situation in which they occur, words can direct us to virtually any knowledge we have or to any relationship we can imagine.

In the above example, knowing the meaning of giraffe does not insure that you will know the meaning of the sentence. Understanding the sentence depends upon your knowledge of giraffes and how they can potentially relate to other things, plus your knowledge of the current situation.

As the above example shows, the relation between words and our knowledge of the world is not rigid and set, but rather, involves a complex, flexible type of problem solving. Understanding is not and can not be a passive taking in or recording of experiences. Understanding always involves an interaction between knowledge of the words and knowledge of related events. Understanding can not occur if we are not familiar with the word used. Conversely, understanding can not occur if we do not have the appropriate knowledge to make sense of the words in a particular situation.

Unless we are aware of this interdependence of knowledge of words and knowledge of the world, it seems natural to assume that understanding will occur automatically if we know the meanings of words. Based upon this assumption, two related instructional errors frequently occur. First, materials often teach vocabulary without providing the background knowledge necessary for understanding. Second, the contents of instructional materials are frequently not understood because the designers assum that a familiarity with their vocabulary is all that is required for understanding them. In both of these cases, instructional materials fail because they assume a given vocabulary is a sufficient condition for understanding to occur.

The third type of design error to be discussed occurs when instructional materials actually interfere with the building of the semantic constructions necessary for understanding. Typically, this happens when the ability to perform a task is confused with the understanding of a concept or principle. Examples of the first type of error are easy to find.

Frequently, learners will be taught the vocabulary of a subject area, but not given the information or experience necessary for them to do the construction involved in understanding related statements or problems. The result is a set of words or facts that are memorized, but not understood. William James in his book *Talks to Teachers* gives a famous example of his failure to understand the contribution of the learner. While visiting a class, a friend of James' asked the students, "if you dug a hole hundreds of feet deep into the earth, would it be hotter or colder at the bottom of the hole?" The student said they didn't know. The teacher replied: "I am sure they know, but I think you don't ask the question quite rightly. Let me try." She then asked, "In what condition is the interior of the globe?" The class responded at once in unison, "The center of the globe is in a state of igneous fusion."

In fact, they knew the vocabulary, but did not have knowledge relevant to the problem. That is, they did not have the knowledge necessary to build semantic constructions relevant to the problem. As we saw in the earlier examples, knowledge of vocabulary is not a guarantee of the ability to do the construction necessary for understanding to occur. Learning the vocabulary of a subject matter need not include learning the information necessary to build relevant constructions. The words don't have meanings which are evoked when the words occur. The words only act as cues for the building of semantic constructions. If the learner doesn't have the necessary knowledge, he cannot create the semantic constructions. If he cannot create the semantic constructions, he cannot understand. The words only act as cues to the building of meaningful interpretations, they do not carry the meaning. To solve the problem the students needed to understand that the earth is shaped like a ball, that as with a ball, when you dig straight down you approach the center, and that the center of the earth contains molton rock. If they had relevant experience, they would then understand that this molton rock would necessarily be extremely hot and, therefore, they would be able to conclude that as you approached this heat source it would become warmer. This knowledge which is needed to solve the problem is not contained in the word meanings in the statement: "The interior of the globe is in a state of igneous fusion." Memorizing this statement or a related vocabulary does not necessarily mean that understanding will occur. To understand the problem posed to the class, a great deal of knowledge of the world is required, knowledge which is not automatically carried by the words or vocabulary items. Often the development of the vocabulary of a content area is given too much attention, while little time is spent developing experiences which provide the required knowledge.

The first type of error, the teaching of vocabulary in the absence of the knowledge necessary for constructive understanding, has an equally nonproductive counterpart; that is, making the assumption that if the vocabulary used is familiar to the learner then understanding will automatically occur. This assumption, at face value, seems natural and reasonable until we consider again the nature of comprehension. Understanding entails being able to make appropriate mental constructions. Usually, the building of these semantic constructions requires a great deal of information not included in the words or sentences making up the instructional materials. In the "building of a birdhouse" example cited above, people frequently thought that they had heard the word "hammer." Their understanding of the sentences was based upon knowledge of hammers, nails, wood, birds, birdhouses, etc., knowledge that was not included in the sentence. If they had not had this extra knowledge they could not have understood the sentences in the same way. To be understood, words must be in the vocabulary of the learner and they must direct the learner to relevant knowledge he has about the topic or issue being referred to. If he has no such knowledge, understanding will not occur. It is, therefore, possible to be familiar with the words used in instructional materials and still not understand the information the materials were designed to convey.

Consider again the sentence. "The haystack was important because the cloth ripped." This sentence is difficult to understand. However, this difficulty is not due to the difficulty or lack of familiarity of the words in the sentence. The sentence is difficult to comprehend because it does not contain enough information to allow us to build an appropriate semantic construction. If we consider this sentence in the context of a parachutist, it is not difficult to build an appropriate construction. If we did not have knowledge of parachutists, parachutes, the speed of free falling objects, etc., the sentence would be impossible for us to understand even though the actual words in it were all familiar to us. Designing instructional materials using a vocabulary level appropriate to the learners is of course a necessary part of instructional design. However, it is only a first step in making the materials understandable to the learners. The learners must have knowledge which can be related in some way to the content of the instructional materials.

It is also possible for the learner to possess appropriate knowledge, i.e., knowledge relevant to the content of the instructional materials, and not be aware of what part of his knowledge he should apply. In the "Washing Clothes" example discussed in the first part of this chapter, we all had the knowledge which could have enabled us to understand the paragraph. However, it was not until we were aware of what aspect of our knowledge was relevant that we were able to understand the

paragraph. If we do not know how our existing knowledge relates to what we are experiencing, then we can not build semantic constructions, and, therefore, understanding does not occur.

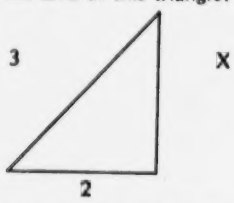
Frequently, instructional material actually interferes with the learners' development of semantic constructions; this is the third type of instructional error we will discuss. Consider the following example taken from George Millers', *The Psychology of Communication.*

> Imagine that you are teaching geometry to children. You have covered the business of calculating the length of the hypotenuse of a right-angled triangle when the base and the altitude are given. Now you are about to take up the problem of finding the *area* of a right triangle when the base and the hypotenuse are given. Suppose you were given your choice of the following two methods of teaching the children to solve the problem. In method A you would help them to discover that the area of a right triangle is half that of a rectangle with the same base and altitude, that the unknown altitude of the triangle in this case can be calculated from the given base and hypotenuse by use of the Pythagorean theorem, and that the area of the triangle can therefore be found by deriving the altitude, computing the area of the rectangle and then taking half of that. In method B you would simply tell the class to memorize six steps: 1) add the length of the base to the length of the hypotenuse; 2) subtract the length of the base from the length of the hypotenuse; 3) multiply the first result by the second; 4) extract the square root of this product; 5) multiply the positive root by the length of the base; 6) divide this product by two.

Method B is an extreme example of how an attempt to be precise and spell out each step in detail can actually interfere with the learner's development of semantic constructions. This procedure for solving the problem does not help the learner to see the relation between the triangle and the related rectangle or the relation of the sides of the triangle to the hypotenuse (see Figure 1). It is this set of relations that must be understood if the learner is to understand the solution to the problem. Following the instructions does not lead to the development of those semantic constructions which are crucial to an understanding of the solution to the problem or to related problems. In fact, following the steps requires such concentration that the student's attention is actually distracted from those aspects of the problem which must be grasped in order for comprehension to occur. All of the learner's effort and attention is required to follow each step exactly and he is actually prevented from building the relevant constructs. In addition to taking up all the learner's

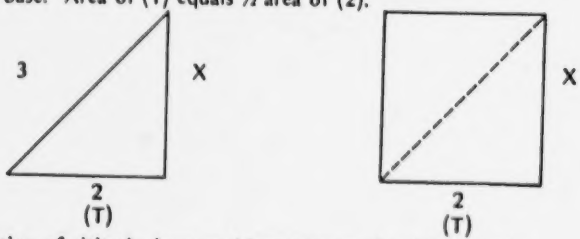
Figure 1. Problem, knowledge relevant to solution, and solution of problem. (See text for discussion.)

PROBLEM: What is the area of this triangle?

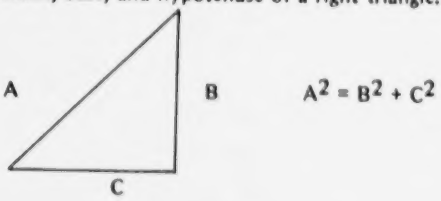


Knowledge crucial for understanding solution:

1. Relation of area of triangle to area of rectangle with identical altitude and base. Area of (1) equals ½ area of (2).



2. Relation of altitude, base, and hypotenuse of a right triangle.



SOLUTION:

A. With knowledge of 2 you can find the altitude, i.e., side X.

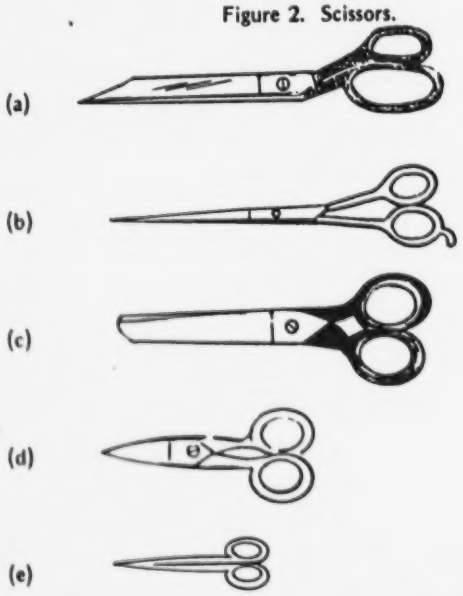
B. With knowledge of 1 you can find the area of the right triangle.

time and attention, the steps also disguise the principles underlying the steps so well that the learner is unable to tell how the steps relate to things he already knows. This procedure is unsuccessful because it distracts the learner from what must be perceived, and it provides no information about what part of the knowledge already possessed is relevant to the solution of the problem. This is not to deny the importance of an analysis of the material into small manageable parts. However, this can be self defeating if the learner is not able to grasp relations between the units or see the purpose of the steps.

Consider the instructions for filling out your income tax forms. These instructions work, in that if you follow them carefully you will be able to complete the task. However, these instructions do not give you much information about what you are doing or why. The steps involved in doing a task need not convey any understanding of what has been done, unless that understanding itself is a desired outcome. But it is important to keep clear the difference between instructions telling how to do a task, such as the assembly of a toy or a piece of furniture, and instructions designed to convey an understanding of what is involved in the solution of a problem or a set of similar problems.

Shaw and Wilson (1976) demonstrated that it is typically the abstract relations or principles underlying instances of concepts that are acquired by learners. These abstract relationships are what allows the learner to use what he has learned in new related situations. Instructional materials which distract the learner from these relations or hide them from him can not be understood in a useful manner.

Figure 2. Scissors.



Next, consider the scissors shown in figure 2. (This figure is taken from Bransford and McCarrol, 1975). Suppose we are assigned the task of developing instructional materials to teach people to correctly identify each of the give types. One procedure would be to develop criteria or define characteristics which when learned would allow the learner to

identify each of the types of scissors. Typically, characteristics such as size of blades, size of handle, shape of blade, shape of handle, shape of blade tips, and weight, might be used. The learner would then be required to learn the six defining characteristics of each type. Once the characteristics of each type had been acquired the learner would have a foolproof set of procedures for identifying the five types of scissors.

What is wrong with such a set of procedures? It is clear that this system once learned would in fact allow the successful identification of the scissors. However, there are a number of problems with such a set of procedures. First, the task of memorizing the six characteristics of each type seems artificial and boring. This is because we have developed instructional materials which do not encourage the building of semantic constructions. We have developed an artificial set of characteristics which do not relate in any apparent way to other knowledge the learner might have. If his knowledge is not relevant or he does see how it is relevant, then he cannot build the constructions which together constitute understanding. That is, he cannot conceptualize the various types of scissors. He is left to the dull, tedious task of memorizing the six criteria for each of the five types.

An alternative would be to develop instructional materials which would allow and encourage the learner to use his existing knowledge to build constructions concerning the given types and their relationships to each other. For example, we could develop materials leading the learner to infer or discover the relation between the structure and function of the scissors. The heavy scissors with the lower blade flush to a surface and with an unusually large finger hole are for cutting cloth. They are heavy in order to cut heavy material, the blade and handle are designed to allow them to slide along a flat surface as they cut, and the large finger hole allows more fingers and therefore stronger pressure to be applied for cutting blades. Now look at the other types; which might be safe for small children? How would large finger holes be helpful to children? Which scissors would be good for cutting hair? Why? Now the learning of the different types seems to progress in a sensible, easy, and straightforward manner. Your existing knowledge is useful and you know which parts of your knowledge are relevant. Now, the task seems so easy as to occur almost automatically. But if you look carefully, you will see your mind at work building constructions, constructions which include the relationships between the uses of the scissors and their principles of design. This understanding does not come automatically, and can come at all only because the constructive process can make use of the existing knowledge you already have. If you were from another culture and did not have the relevant knowledge, you would once again be in the position of memorizing unrelated facts.

Too much of what we teach people is taught as isolated facts that don't relate the rest of their knowledge. I have interviewed children who had recently finished a 6th grade science curriculum. When asked about cells, they seemed to have learned a considerable amount. They know about cell walls, cell nuclei, and the division of cells. However, when asked about where cells were, and what things had cells, they looked at me with a blank stare. Clearly, they had no idea which part of their already existing knowledge was relevant to the information they had been learning about cells. They had not used relevant aspects of their existing knowledge in building their constructions about cells. The constructions that were built were not related to other things the children knew.

In each of the three types of errors discussed, the instructional materials failed because the learner did not build an appropriate semantic construction. In the first type, the learner is taught vocabulary items while little attention is paid to the teaching of relevant background knowledge. Without the relevant background knowledge he is unable to build the necessary semantic constructions. In the second case, he is unable to build the appropriate constructions even though the words are familiar to him, because he does not have the necessary background knowledge which would enable him to understand the context of the materials. In the third case, the instructional materials actually prevented the learner's development of appropriate constructions.

In some research recently conducted at Governors State University (Wilson, Hilligoss and Vasto, 1977) we conducted a strong test of the necessity of semantic constructions for learning. We gave two groups of students the same list of sentences to learn. The sentences were short and expressed simple facts such as "Uncles are male." and "Squares have corners." All of the words in the sentences were common English words. Students in one group were given instructions designed to prevent them from building semantic constructions. As they read each sentence this group checked to see if the nouns in the sentence rhymed. Another group of students was given a task designed to encourage the building of semantic constructions. As these students read each sentence, they were asked to rate the contents of the sentences, as pleasant or unpleasant to them. Presumedly, rating the contents of these sentences referring to uncles as pleasant or unpleasant caused the learner to think about an uncle of his, or an imaginary uncle, or an uncle in a story, etc. This is the building of a semantic construction. Later, both groups were given the sentences in the form "_____ are male" and asked to recall as many of the subjects of the sentences as possible. Members of the group who

performed the task designed to interfere with the formation of semantic constructions could recall only about 4 of the 50 subjects. In contrast, members of the group who performed the task encouraging the development of semantic constructions were able to recall more than 30 of the original sentences. This is a striking result when it is noted that both groups of students experienced the same set of sentences the same number of times (once) and for the same amount of time. The acquisition of simple facts, presented in small units, and in a simple vocabulary, failed to teach when semantic constructions were not built.

We have seen that 1) understanding is a problem solving activity which entails constructing semantic interpretations. 2) To be successful at this task the listener must have appropriate background knowledge and 3) must know what aspects of this knowledge are relevant to the understanding of the material at hand. Knowing the meanings of words used in the material is not a sufficient basis for understanding prose. The problem is not simply a vocabulary problem. Rather, the problem of understanding is one of satisfying sufficient conditions for the construction of semantic interpretations to take place. To be successful, instructional strategies and materials must bring the learner to use his knowledge to develop these mental constructions.

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